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MUNICIPAL WATER TREATMENT INVENTORIES OF HISTORICAL SIGNIFICANCE - 1910 and 1915

Ralph Porges

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

January 1958

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Water Supply and Water Pollution Program
Robert A. Taft Sanitary Engineering Center, USPHS
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MUNICIPAL WATER TREATMENT INVENTORIES

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Introduction

The recorded history of public water supplies in the United States, although somewhat clouded with time, establishes the existence of a supply in Boston in 1652[1]. The second and third supplies in this country were at Schaefferstown, Pennsylvania in about 1732 and Bethlehem, Pennsylvania in 1761. It is interesting to note that Moses of the Pennsylvania Department of Health, in a recent presentation on "Early Pennsylvania Water Supplies ",[2] states that "The oldest public water works in Pennsylvania, and perhaps in the United States, is that of Schaefferstown, Lebenon County (population 900)". The date of construction is given as 1736. No doubt the interpretation of 'public water works' may cause these differences in opinion. The establishment of additional water supplies and the advent of treatment have been well reported both by the excellent Manual of Water Works Practice[1] of the AWWA and the fine treatise "The Quest for Pure Water"[3].

Summarizing briefly, in the year 1800, 17 water works were in existence. This number was doubled by 1825 and reached 100 by 1850. Twenty-five years later they totalled 243, and by 1885 there were 1000 water works in operation; a decade later, 1895, there were 3000 works. It was apparent that water works installations were endeavoring to

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keep up with our rapidly expanding urban population. Also, it was during this time, the late 1880's, that water treatment first was practiced on a large practical scale. In 1897 there were about 100 rapid sand and a dozen or so slow sand filter plants.

The Manual of Water Works Practice, 1925[1] states, after the 1895 entry: "Here, complete half-decade records stop, but from the best figures available it is estimated that there were over 9,000 water works in the United States and its possessions at the close of 1924, supplying 10,100 communities". Thus for nearly 30 years during vital episodes in water supply practice - the large increase in water supplies and water treatment works, the beginning and widespread use of chlorination, and the subjugation of typhoid fever as a water-borne disease - there appears a paucity of records. It is probable that the Wars of 1898 and 1917 and the depression between these years prevented devotion of effort to such summation activities.

Consequently, it was extremely interesting to analyze an unpublished tabulation uncovered in the files of the Basic Data Inventory and Analyses Unit, Robert A. Taft Sanitary Engineering Center, U. S. Public Health Service, titled as follows:

MUNICIPAL PLANTS[4]
Water Treatment in the United States
From data available at
Stream Pollution Investigation Office
Cincinnati, Ohio

Compiled by
R. E. Tarbett (now deceased)
Associate Sanitary Engineer

The report, listing individual water works by States and describing briefly the treatment process, was divided into two groupings, one show-

ing installations prior to 1911 and the other for a period after 1911 which was established to be effective as of 1915.

Inventory Dates

It was essential to ascertain the date of the post 1911 tabulations; the prior to 1911 record obviously establishing a 1910 inventory. Unfortunately, there was no assembly date on the report, although the 1910 U. S. Census populations were recorded in the tabulations. A brief review of the Sanitary Engineering Center files revealed correspondence regarding the subject material with numerous States during the latter half of the second decade. A letter on this subject dated September 25, 1920 to Chief Sanitary Engineer, V. M. Ehlers, Texas State Board of Health, from R. E. Tarbett states: "During the period 1914 to 1917, over 500 cities were surveyed by the personnel attached to this Station". These were "Sanitary surveys of communities made in connection with preliminary extra cantonment zone sanitation". After establishing the general inventory period, the individual entries were checked against files and records[6,7] and other data[5]. From this comparision, it was determined that the effective date for the later inventory would be 1915.

Inventory Limitations

There are certain limitations to the assembled data. As indicated by the inventory title, the information is limited to treatment plants and so excludes the numerous water systems not having treatment facilities. Also the record was presented as not being complete. A State

by State review showed that data of only 6 states - Iowa, Maine, Massachusetts, New Hampshire, New Jersey, and Texas - were claimed to be fairly complete. However, the report carries the following explanatory notes: "The filter plants listed comprise at least 85 per cent of the filtration plants that are now in operation in the United States, and the population served by these plants is at least 98 per cent of the total population served by filtration plants.

"The list of filter plants having chlorination as an added adjunct and of chlorination plants with no other treatment of the water is rather incomplete.

"Chlorination was first used in 1909 and came into rather general use after 1912. Since 1915, there have been a large number of supplies both filtered and raw which have installed chlorination. The record of these installations is not available at present."

Even with its inherent limitations, the report is of considerable value and fills a very obvious void during a vibrant period in Water Works practice.

Presentation of Data

The data for each State have been summarized by number of communities and by 1910 U. S. Census populations. Appendix A presents the 1910 data and Appendix B, the 1915 data. The categories established include: total number of communities with treated water; filtration by rapid sand (mechanical), slow sand, and pressure filters; coagulation, including a few miscellaneous installations; chlorination only; and a grouping of all installations practicing chlorination.

Table 1 contains a summary of the two inventories. In 1910, there were 557 water treatment works which 5 years later, in 1915, had increased to 830. By 1910 Census figures, the population of the communities served in 1910 was about 13,900,000 and in 1915 totalled approximately 22,700,000.

Filter plants totalled 519 in 1910 and 680 in 1915. In 1910, there were 427 rapid sand filters, 65 slow sand filters and 33 pressure filters. Comparable statistics for 1915 show 576 rapid sand filters, 69 slow sand filters, and 41 pressure filters. Coagulation and miscellaneous increased from 34 to 42 installations from 1910 to 1915.

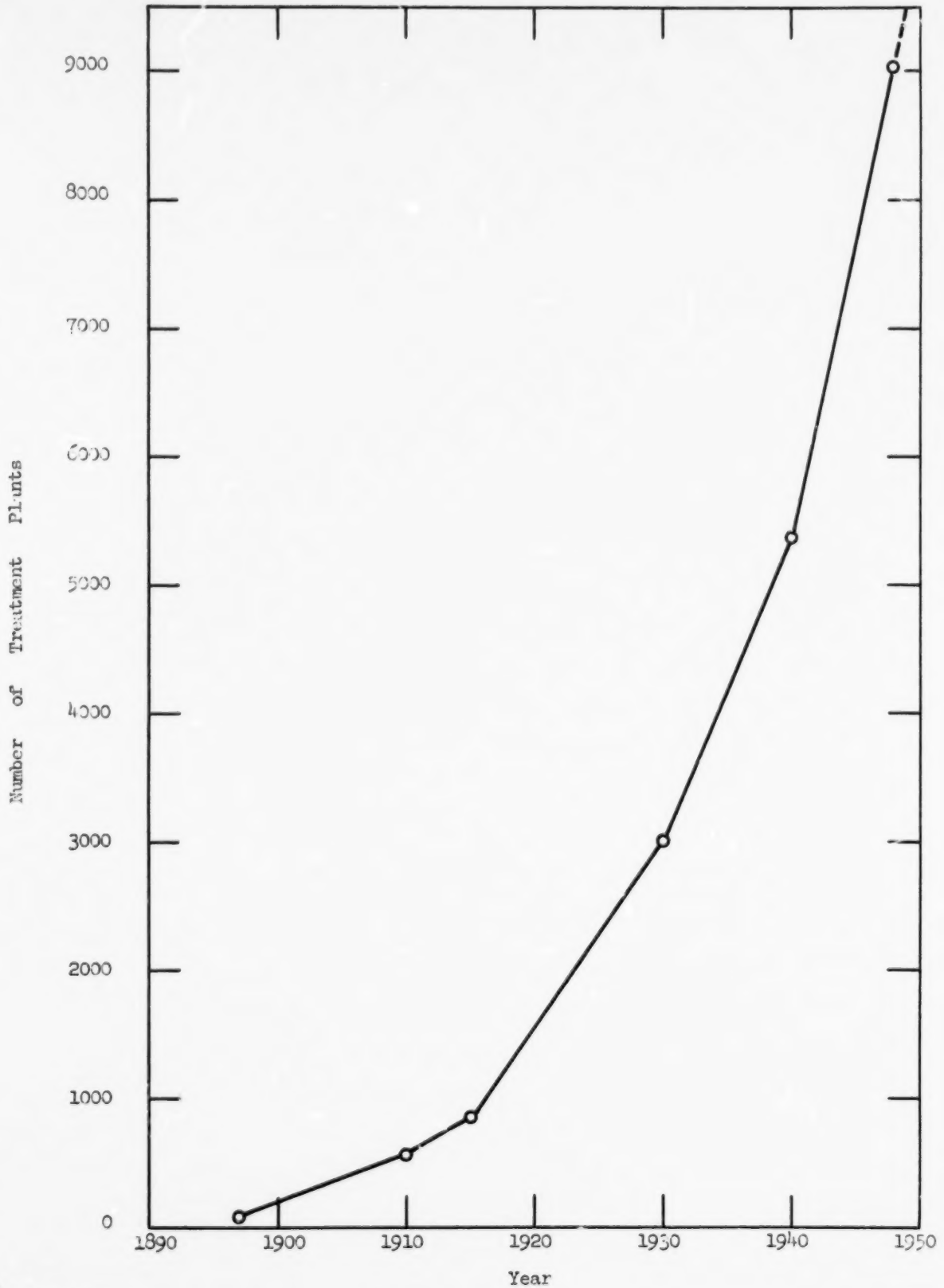
Chlorination as the sole treatment process was practiced in only four instances in 1910; this jumped to 108 in 1915. More significantly, from 18 installations using chlorine disinfection and serving about 1,180,000 people in 1910, a rapid increase took place to 340 such installations serving 15,580,000 people in 1915.

Discussion

A review of published records pertaining to the number of communities with treated water shows about 115[1] in the year 1897, 3015[8] in 1930, 5372[9] in 1940, and 9078[10] in 1948. The 1910 and 1915 data herein presented reported 557 and 830 plants respectively. These data are plotted in Figure I and depict the rapid increase in treatment plants, that is apparently continuing beyond our present time.

In 1910 there were reported 519 filter plants and in 1915, 680 filter plants, the increase due primarily to rapid sand installations. This last figure may be compared to the 634 filter plants reported by

Figure 1. Growth of Water Treatment Plants in the United States



Gillespie[5] in 1924. Since the latter number referred to plants having capacities of 1 MGD and over, many smaller plants were no doubt omitted. On a population basis, 23,664,000 were served in 1924 as compared to about 17,100,000 in 1915 and 13,000,000 in 1910. Referring to Figure 1, it can be estimated that there were about 1800 treatment plants in 1924.

The most striking trend shown by comparison of the 1910 and 1915 data was the rapid increase in the use of chlorination as a disinfecting agent. Even with admittedly incomplete records, chlorination as the sole treatment process increased from 4 to 108 and all plants using chlorination jumped from 18 to 340. The effect of chlorinated water supplies on the typhoid rate is now recorded history.

It has been reported elsewhere[11] that the estimated population served with filtered water totalled about 10,600,000 in 1910 and 17,300,000 in 1914. This compares reasonably close with the Tarbett data.

It is apparent that the relationship of the 1910 and 1915 data with other records affirmsthe statement in the original compilation that the inventory data were at least 85 per cent complete as to number of plants and 98 per cent complete as to population served. Although census populations were used in these inventories, many systems and water works companies not readily identified with a specific community did not carry population statistics and accordingly counterbalanced the use of census figures which probably were larger than the population served in many instances.

An estimate of the total number of water systems in 1915 might be of interest. The Water Works Progress Inventory of Pennsylvania compiled by the State Water Supply Commission from returns collected in

1914 showed 676 municipalities having public water supplies[1] as compared to 97 treatment plants shown for 1915, a ratio of about 7 to 1 for systems versus plants. It is estimated that for the entire country, there would have been about 5,800 water systems in existence in 1915. This may be compared to 3,000 reported in 1895 and 9,000 estimated for 1924.

There appears to be some differences of opinion regarding what constituted water treatment. For example, settling was practiced before the time of these inventories by many communities using river water, such as Kansas City and St. Louis, Missouri. Yet these communities were not included in the statistics. Apparently, the State Health Department did not consider settling a treatment process. Texas, the only State to report settling, showed no coagulation plants. Possibly the term 'settling' was applied to coagulation and sedimentation installations in this instance. The original report totalled these installations under a single item: "Coagulation and sedimentation plants".

Several miscellaneous points of interest were brought out by the original inventories. One plant with ozone sterilization was listed. In 1910, one iron removal and two softening plants were in operation. By 1915, 4 sofenting and 5 iron removal units and 1 carbon dioxide removal plant were recorded.

Summary

Summary data of two unpublished inventories of water treatment practices with established effective dates of 1910 and 1915 have been presented. These records fill a void in the published accounts of water treatment plants during the rise in rapid sand filtration and during the time chlorination became accepted. This was the period of striking decrease in typhoid fever rates, e.g., in 17 cities, the annual typhoid

death rate per 100,000 in 1905 ranged from 13 to 99; in 1920 the range was 1.1 to 7.0.

In 1910, there were reported 557 treatment plants including 519 filter units, 34 coagulant and miscellaneous installations and 4 simple chlorination plants; a total of 18 practiced chlorination. By 1915, the number of water treatment installations increased to 830, with 680 filter plants, 42 with coagulation and miscellaneous treatment, and 108 practicing chlorination only; 340 installations used chlorination for disinfection. The data are purported to represent at least 85 per cent of the water treatment installations serving over 98 per cent of the total population served by treatment facilities.

Acknowledgment.

Full acknowledgment is made of the efforts of the late Sanitary Engineer Director, R. E. Tarbett; these inventories are truly his work. They resulted from his interest in this activity, the need for such data, and the opportunity afforded by the numerous water supply and sewage surveys and extra cantonment health work conducted by field personnel of the U. S. Public Health Service prior to and at the time of the first world conflict.

TABLE I. SUMMARY, MUNICIPAL WATER TREATMENT PLANTS

Communities and types of treatment	1910		1915	
	No.	Pop. figures* based on 1910 Census	No.	Pop. figures * based on 1910 Census
Communities	557	13,912,147	830	22,736,688
Filters-total	519	12,971,984	680	17,095,893
-rapid sand	427	7,026,089	576	10,575,151
-slow sand	65	5,031,328	69	5,154,033
-pressure	33	914,531	41	1,366,709
Coagulation and misc.	34	648,043	42	737,900
Chlorination only	44	292,156	108	4,902,895
Total using chlorination	18	1,179,636	340	15,576,197

Note: Types of filters not additive as more than one type of filter may be installed at a single plant.

*See Appendix A and B

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Appendix A

Summary of Water Treatment Practice - 1910

STATE	Communities		Filters								Coagulation or Miscellaneous		Disinfection Only		Disinfection Total	
			Total		Rapid Sand		Slow Sand		Pressure							
	No.	1910 Census Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
ALABAMA	6	163,218	6	163,218	4	154,225	1	4,734	1	4,259	-	-	-	-	-	-
ARIZONA	1	2,914	1	2,914	-	-	1	2,914	-	-	-	-	-	-	-	-
ARKANSAS	5	77,664	4	66,726	2	60,375	-	-	2	6,351	1	10,938	-	-	-	-
CALIFORNIA	9	545,514	9	545,514	3	31,506	-	-	6	514,008	-	-	-	-	-	-
COLORADO	7	240,149	7	240,149	4	14,938	3	225,211	-	-	-	-	-	-	-	-
CONNECTICUT	7	191,864	6	173,024	3[a]	14,155	3[a]	142,406	1	16,463	-	-	1	18,840	1	18,840
DELAWARE	1	87,411	1	87,411	1[a]	43,705	1[a]	43,706	-	-	-	-	-	-	1	87,421
DISTRICT OF COLUMBIA	1	331,069	1	331,069	-	-	1	331,069	-	-	-	-	-	-	-	-
FLORIDA	1	3,082	-	-	-	-	-	-	-	-	1[e]	3,082	-	-	-	-
GEORGIA	26	349,751	25	346,751	21	183,704	3	8,208	1	154,839	1	3,000	-	-	-	-
IDAHO	1	1,155	1	1,155	-	-	1	1,155	-	-	-	-	-	-	-	-
ILLINOIS	22	341,196	21	338,696	17	253,292	-	-	4	85,404	1	2,500	-	-	-	-
INDIANA	13	459,485	13	459,485	11	225,089	1	233,650	1	7	-	-	-	-	-	-
IOWA	10	169,821	10	169,821	7	103,319	-	-	3	66,502	-	-	-	-	-	-
KANSAS	27	212,557	22	166,340	20	159,635	2	6,705	-	-	5	46,217	-	-	-	-
KENTUCKY	13	366,590	9	316,188	7	303,083	-	-	2	13,105	4[f]	50,402	-	-	-	-
LOUISIANA	4	380,066	4	380,066	4	380,066	-	-	-	-	-	-	-	-	-	-
MAINE	9	50,800	9	50,800	7	42,390	2	8,410	-	-	-	-	-	-	-	-
MARYLAND	5	21,953	5	21,953	5[a]	21,953	1[a]	-	-	-	-	-	-	-	-	-
MASSACHUSETTS	7	234,265	6	127,971	2	14,354	4	113,617	-	-	1[g]	106,294	-	-	3	16,507
MICHIGAN	6	61,752	6	61,752	4	51,595	-	-	2	10,157	-	-	-	-	-	-
MINNESOTA	8	27,708	8	27,708	7	24,566	1	3,142	-	-	-	-	-	-	-	-
MISSISSIPPI	5	76,373	5	76,373	5	76,373	-	-	-	-	-	-	-	-	-	-
MISSOURI	22	235,177	19	207,596	19	207,596	-	-	-	-	-	-	-	-	-	-
MONTANA	2	5,218	2	5,218	1	4,697	1	521	-	-	3	27,581	-	-	-	-
NEBRASKA	2	129,584	1	5,488	1	5,488	-	-	-	-	1	124,096	-	-	-	-
NEVADA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEW HAMPSHIRE	7	47,494	7	47,494	3	22,395	4	25,099	-	-	-	-	-	-	1	11,780
NEW JERSEY	36	400,781	34	131,001	21[bc]	72,404	5	15,900	10[b]	42,697	-	-	2	269,780	2	269,780
NEW MEXICO	1	395	1	395	1	395	-	-	-	-	-	-	-	-	-	-
NEW YORK	48	2,765,018	48	2,786,018	34[a]	1,415,070	15[a]	1,370,948	-	-	-	-	-	-	-	-
NORTH CAROLINA	27	203,083	27	203,083	26	202,106	1	977	-	-	-	-	-	-	-	-
NORTH DAKOTA	2	18,666	2	18,666	2	18,666	-	-	-	-	-	-	-	-	1	7,188
OHIO	26	913,124	26	913,124	24	898,026	2	15,098	-	-	-	-	-	-	-	-
OKLAHOMA	16	137,701	12	127,074	12	127,074	-	-	-	-	4	10,627	-	-	-	-
OREGON	6	23,041	6	23,041	5	22,626	1	415	-	-	-	-	-	-	-	-
PENNSYLVANIA	78	3,058,897	78	3,058,897	71	859,898	7	2,198,999	-	-	-	-	-	-	1	533,905
RHODE ISLAND	7	289,239	7	289,239	6	64,913	1	224,326	-	-	-	-	-	-	-	-
SOUTH CAROLINA	13	152,411	13	152,411	13	152,411	-	-	-	-	-	-	-	-	2	29,192
SOUTH DAKOTA	4	23,225	3	22,025	2	19,885	1	2,140	-	-	1	1,200	-	-	1	5,791
TENNESSEE	6	208,690	5	98,326	5	98,326	-	-	-	-	1	110,364	-	-	3	153,516
TEXAS	27	332,791	17	305,141	17	305,141	-	-	-	-	9[d]	24,114	1	3,536	1	3,536
UTAH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VERMONT	3	28,566	3	28,566	3	28,566	-	-	-	-	-	-	-	-	-	-
VIRGINIA	14	302,821	13	175,193	13	175,193	-	-	-	-	1	127,628	-	-	1	33,190
WASHINGTON	2	8,548	2	8,548	2	8,548	-	-	-	-	-	-	-	-	-	-
WEST VIRGINIA	7	87,197	7	87,197	7	87,197	-	-	-	-	-	-	-	-	-	-
WISCONSIN	7	123,123	7	123,123	5	71,145	2	51,978	-	-	-	-	-	-	-	-
WYOMING	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	557	13,912,147	519	12,971,948	427	7,026,089	65	5,031,328	33	914,531	34	648,043	4	292,156	18	1,179,636

(a) One community both Frs & Fgs
(b) Two communities both Frs & Fps
(c) One unidentified filter
(d) Listed as settled
(e) Softening
(f) Incl. one softening plant-4533 pop.
(g) Iron Removal
(h) Inc. two softening plants-20,544 pop.
(i) CO_2 Removal

Appendix B

Summary of Water Treatment Practice - 1915

STATE	Communities		Filters								Coagulation or Miscellaneous		Disinfection Only		Disinfection Total	
			Total		Rapid Sand		Slow Sand		Pressure							
	No.	1910 Census Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population	No.	Population
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
ALABAMA	9	229,835	9	229,835	7	220,842	1	4,734	1	4,259	-	-	-	-	4	199,302
ARIZONA	1	2,914	1	2,914	-	-	1	2,914	-	-	-	-	-	-	-	-
ARKANSAS	8	105,740	7	94,802	5	88,451	-	-	2	6,351	1	10,938	-	-	2	69,916
CALIFORNIA	16	981,144	15	968,365	7	37,445	-	-	8	930,920	-	-	1	12,779	1	12,779
COLORADO	8	284,544	8	284,544	5	59,333	3	225,211	-	-	-	-	-	-	-	-
CONNECTICUT	11	466,190	8	300,158	4[a c]	113,070	3[a]	142,406	2	44,682	-	-	3	146,032	4	279,637
DELAWARE	1	87,411	1	87,411	1[a]	43,705	1[a]	43,706	-	-	-	-	-	-	1	87,411
DISTRICT OF COLUMBIA	1	331,069	1	331,069	-	-	1	331,069	-	-	-	-	-	-	-	-
FLORIDA	3	45,385	-	-	-	-	-	-	-	-	2[e]	6,861	1	38,524	1	38,524
GEORGIA	29	359,559	28	356,559	25	197,579	2	4,141	1	154,839	1	3,000	-	-	4	50,936
IDAHO	3	9,013	2	6,413	-	-	2	6,413	-	-	-	-	1	2,600	1	2,600
ILLINOIS	42	2,678,865	33	406,656	27	317,043	1	4,209	5	75,404	1	2,500	8	2,269,709	22	2,533,621
INDIANA	21	582,340	15	487,348	13	252,952	1	233,650	1	746	-	-	6	94,992	15	535,833
IOWA	22	379,356	16	197,536	12	128,618	-	-	4	68,918	1	29,292	5	152,528	18	364,813
KANSAS	39	267,015	33	216,151	31	209,446	2	6,705	-	-	4	44,982	2	5,882	11	50,205
KENTUCKY	20	413,505	14	345,459	12	332,354	-	-	2	13,105	5[h]	66,413	1	1,633	7	289,824
LOUISIANA	4	380,066	4	380,066	4	380,066	-	-	-	-	-	-	-	-	2	367,090
MAINE	12	138,792	11	80,221	9	71,811	2	8,410	-	-	-	-	1	58,571	2	83,374
MARYLAND	16	657,231	10	638,421	10[a]	638,421	1[a]	-	-	-	-	-	6	18,810	12	649,298
Massachusetts	12	373,156	7	216,897	2	14,354	5	202,543	-	-	4[g]	144,855	1	11,404	1	11,404
MICHIGAN	20	365,734	10	237,045	8	226,888	-	-	2	10,157	-	-	10	128,689	13	294,627
MINNESOTA	14	428,983	10	336,675	9	333,533	1	3,142	-	-	-	-	4	92,308	6	401,400
MISSISSIPPI	5	76,373	5	76,373	5	76,373	-	-	-	-	-	-	-	-	-	-
MISSOURI	30	1,024,663	26	965,232	26	965,232	-	-	-	-	3	27,581	1	11,850	12	934,128
MONTANA	5	14,584	4	10,960	3	10,439	1	521	-	-	-	-	1	3,624	1	3,624
NEBRASKA	4	177,322	1	5,488	1	5,488	-	-	-	-	1	124,096	2	47,738	3	171,834
NEVADA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEW HAMPSHIRE	9	58,716	7	47,404	3	22,395	4	25,099	-	-	1[f]	1,039	1	10,183	3	23,763
NEW JERSEY	64	695,199	52	258,105	34[b c]	194,877	5	15,900	13	47,328	1[i]	-	13	437,094	31	677,520
NEW MEXICO	2	4,934	2	4,934	2	4,934	-	-	-	-	-	-	-	-	-	-
NEW YORK	66	3,360,728	57	2,852,182	40[a]	1,452,855	17[a]	1,399,327	-	-	-	-	10	538,546	32	1,524,641
NORTH CAROLINA	34	229,617	34	229,617	33	228,640	1	977	-	-	-	-	-	-	12	130,105
NORTH DAKOTA	4	76,830	4	76,830	4	76,830	-	-	-	-	-	-	-	-	3	18,666
OHIO	39	1,769,346	39	1,769,346	37	1,754,248	2	15,098	-	-	-	-	-	-	18	1,601,164
OKLAHOMA	26	95,619	22	74,992	22	74,992	-	-	-	-	4	10,627	-	-	4	87,203
OREGON	9	30,024	8	26,127	7	25,712	1	415	-	-	-	-	1	3,897	2	5,735
PENNSYLVANIA	97	3,193,315	86	3,094,875	79	895,876	7	2,198,999	-	-	-	-	11	98,440	53	2,854,428
RHODE ISLAND	7	289,239	7	289,239	6	64,923	1	224,326	-	-	-	-	-	-	-	-
SOUTH CAROLINA	16	174,011	16	174,011	16	174,011	-	-	-	-	-	-	-	-	3	46,709
SOUTH DAKOTA	4	23,225	3	22,025	2	19,885	1	2,140	-	-	1	1,200	-	-	1	5,791
TENNESSEE	7	212,697	6	102,333	6	102,333	-	-	-	-	4	110,364	-	-	3	103,516
TEXAS	38	432,605	22	343,005	22	343,005	-	-	-	-	10[d]	26,524	6	63,076	8	93,037
UTAH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VERMONT	3	28,566	3	28,566	3	28,566	-	-	-	-	-	-	-	-	-	-
VIRGINIA	16	336,517	14	179,395	14	179,395	-	-	-	-	1	127,628	1	29,494	6	218,543
WASHINGTON	6	135,938	2	8,548	2	8,548	-	-	-	-	-	-	4	127,390	6	135,935
WEST VIRGINIA	13	160,928	10	90,747	10	90,747	-	-	-	-	-	-	3	70,181	7	105,730
WISCONSIN	12	566,817	8	139,856	6	87,918	2	51,978	-	-	-	-	4	426,921	5	441,531
WYOMING	2	1,028	2	1,028	2	1,028	-	-	-	-	-	-	-	-	-	-
TOTAL	830	22,736,688	680	17,095,893	576	10,575,151	69	5,154,033	41	1,366,709	42	737,900	108	4,902,895	340	15,576,197

(a) One Community both Frs and Fgs
(b) One Community both Frs and Fps
(c) One unidentified filter
(d) Listed as settled
(e) Softening
(f) Iron removal
(g) Inc. 2 softening plants-20,544 pop.
(h) Inc. 2 softening plants-20,544 pop.
(i) CO_2 Removal

12.